

Incorporating Spatial Analysis in Invasive Species Assessments

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Spatial Dynamics affect Economic Impacts

- n Regional differences affect the economic impact of regulations— need spatially disaggregated analyses
- n Not just the total population number but also the spatial arrangement impacts capacity to grow, achievement of threshold levels, and marginal effect on yields
- n Costs vary by region (monetary and political)
 - n S.F. Bay Area - Medfly and Malathion Aerial spraying (1980s)
 - n Miami - homeowner citrus tree removal, citrus canker
- n Habitat Quality depends on area, shape, length of edges i.e. the fragmentation of land-uses
- n Location of introduction affects ability to eradicate at low populations

Invasives and Spatial Dynamics

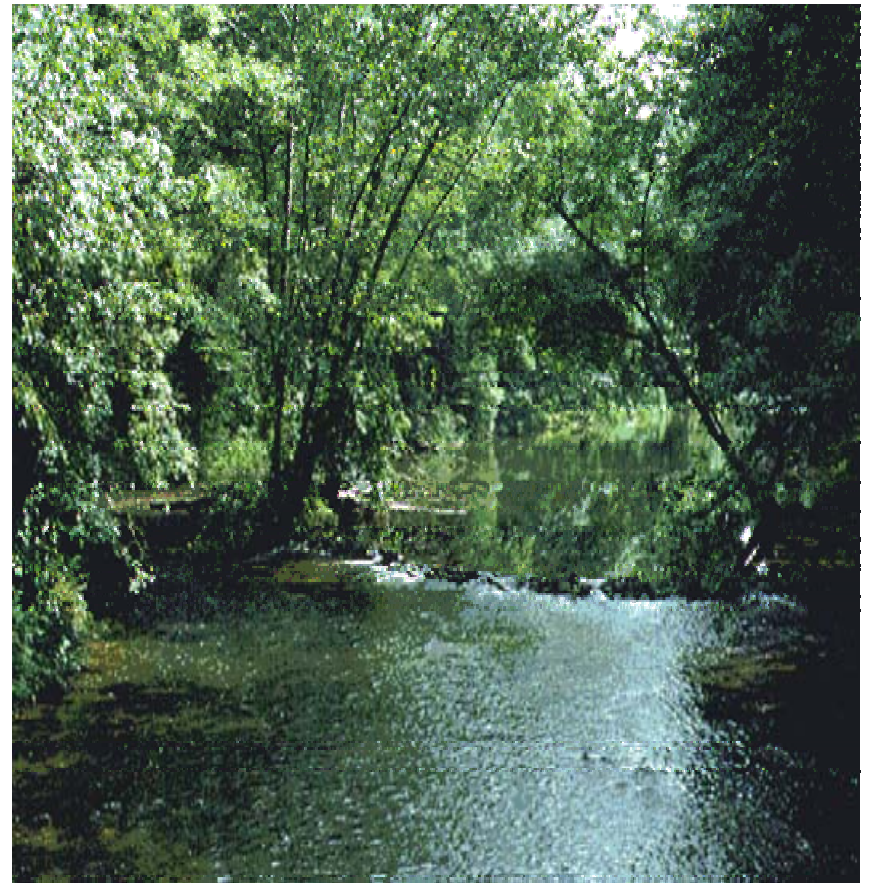
- n Spatial arrangement 1) of habitat, 2) of land use, and 3) of trade and travel patterns have a big impact on:
 - n species movement
 - n species survival
 - n species habitat range
- n Human actions: where are markets, who trades in them, how much trade, what are relevant species in trade partners' regions
- n Human conversion of land –travel networks and how well species survive
- n Natural pathways: such as weather, species mobility
- n Changes in climatic conditions – global warming, el Nino

Infrastructure like Roads, Ports and Airports Promotes Introduction and Movement



Pests need a natural pathway or human transport to go from one point to another
More pathways increase the probability of dispersion.

Species survival depend on characteristics of ecosystem

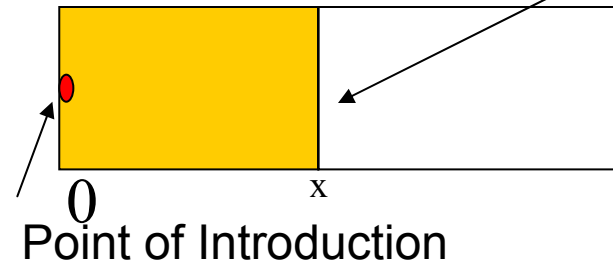


Introductions are less relevant if species can not survive and become established
Can target “good” habitat areas

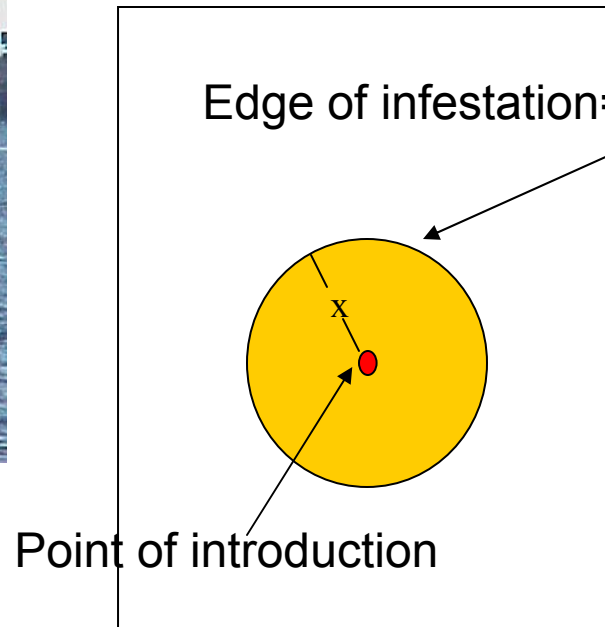
Point of introduction and habitat shape is important to determining rate and pattern of spread



Edge of infestation = Length at $x = L$



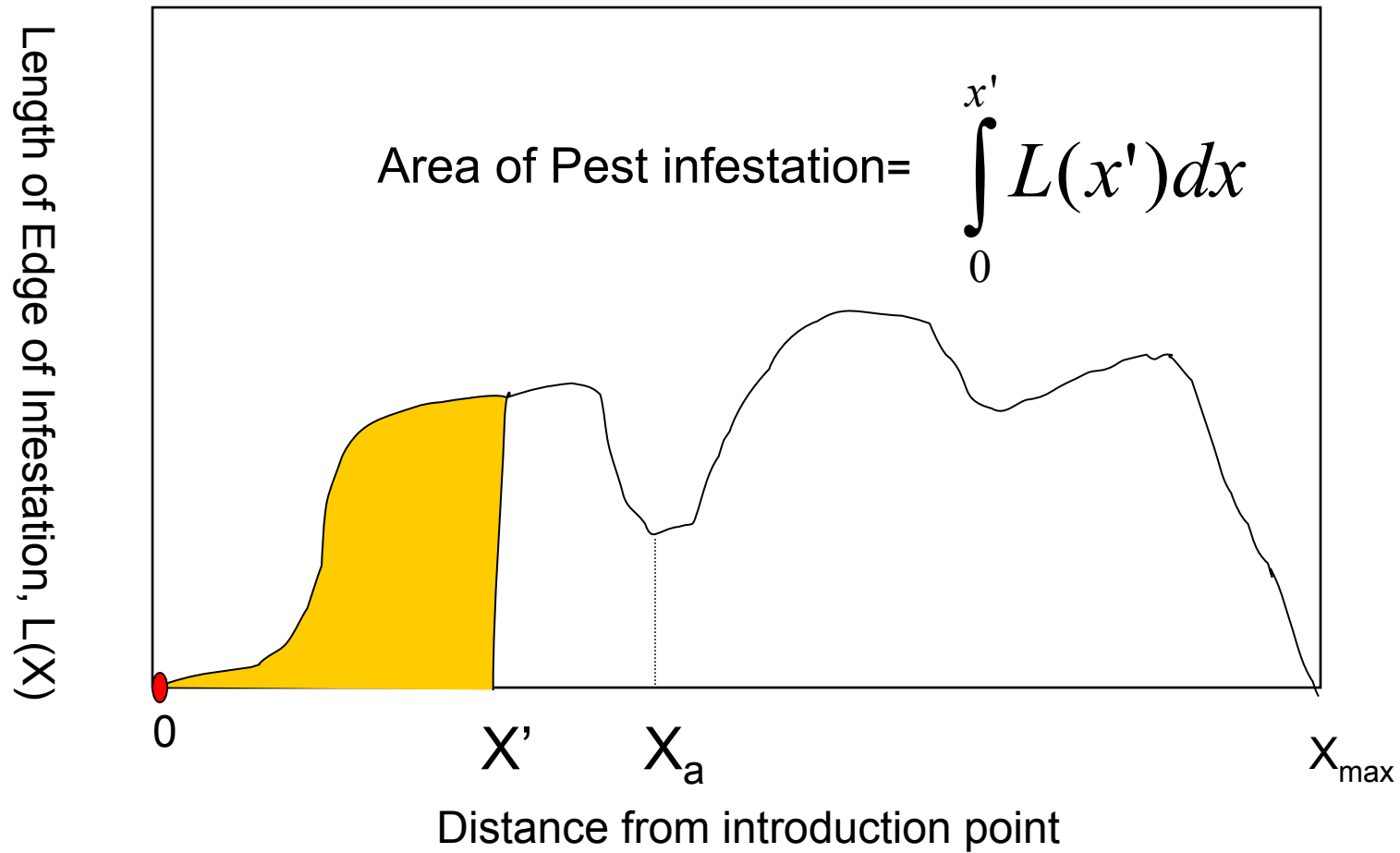
Edge of infestation = length at $x = 2\pi x$



Space is important to defining where to target resources

- n Many models of invasive species implicitly assume homogenous landscapes: policy choice is prevent, eradicate, slow spread, or manage
- n Yet, the optimal decision may depend on the heterogeneity of the landscape
- n Like many environmental problems, the benefits and/or costs of a policy may vary by region.
- n Thus all four policies may be optimal at different points in the landscape.

Less Costly to Slow or Stop the Spread at X_a than at X'



Sharov and Liebhold, 1998

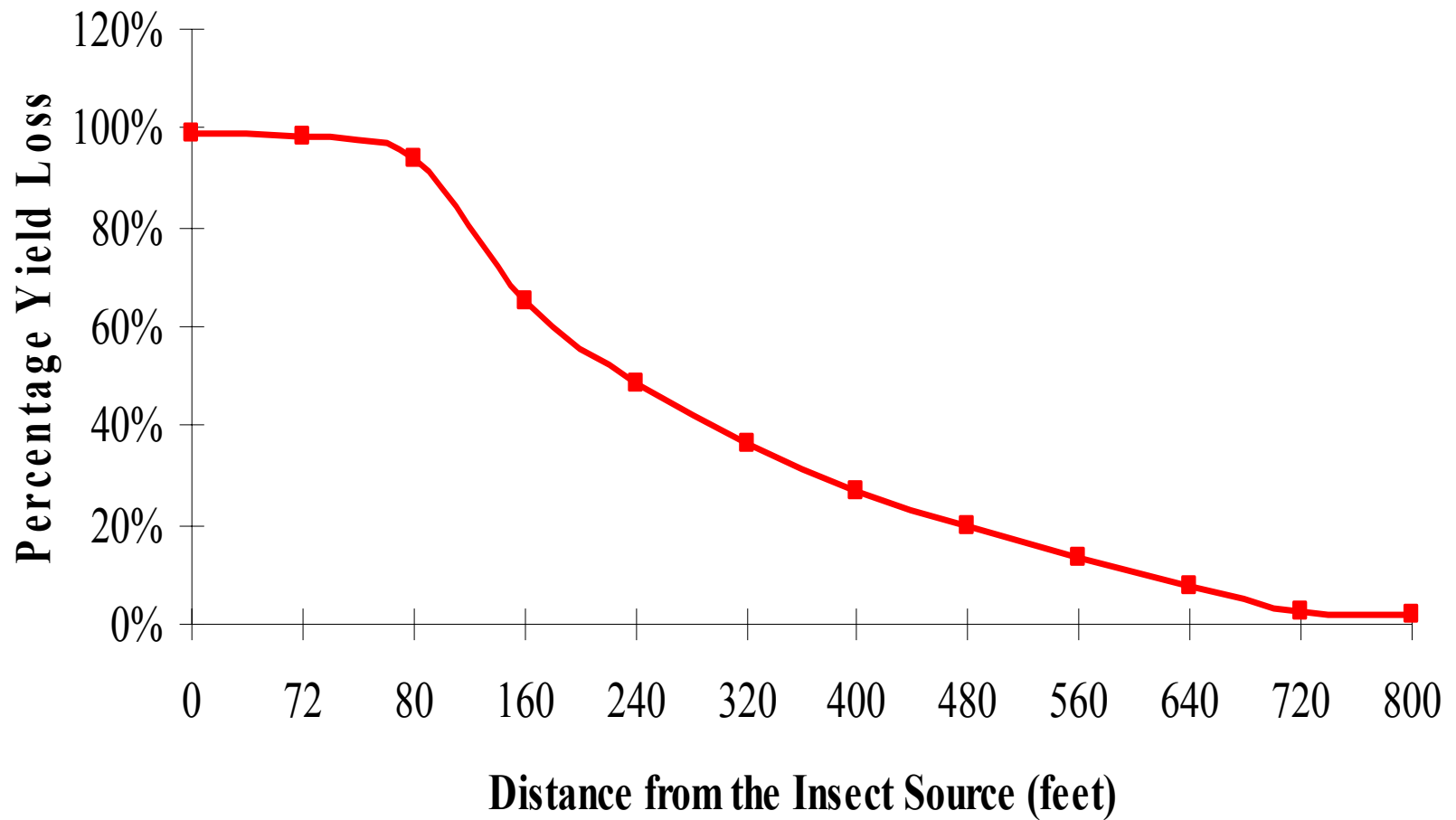
Consider Both Pattern and Population Size

- n A mile of riparian buffers located on lower order streams has more impact on water quality than a mile on higher order streams.
- n It's the number and the spatial distribution of houses that has led to greater air pollution and water quality issues
- n Should we decrease the invasive species below its economic threshold everywhere?
- n Should we eradicate in certain locations and do no or limited control elsewhere?
- n Should we slow spread at x' or at x_a ?
- n What is the value of crops or resources lost in each area
- n Size of habitat impact on dispersal
- n Interaction between disconnected habitat areas

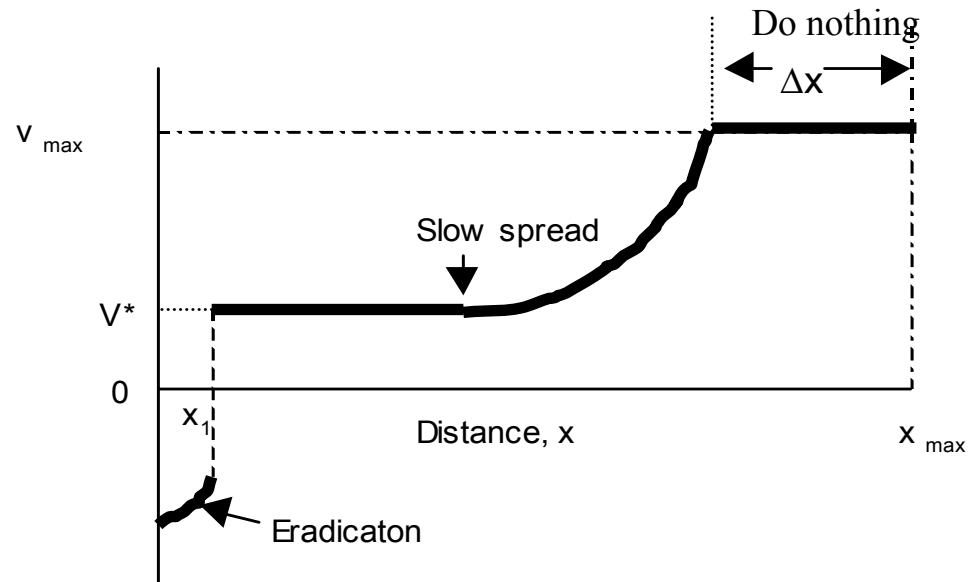
Pierce's Disease in Wine Grapes



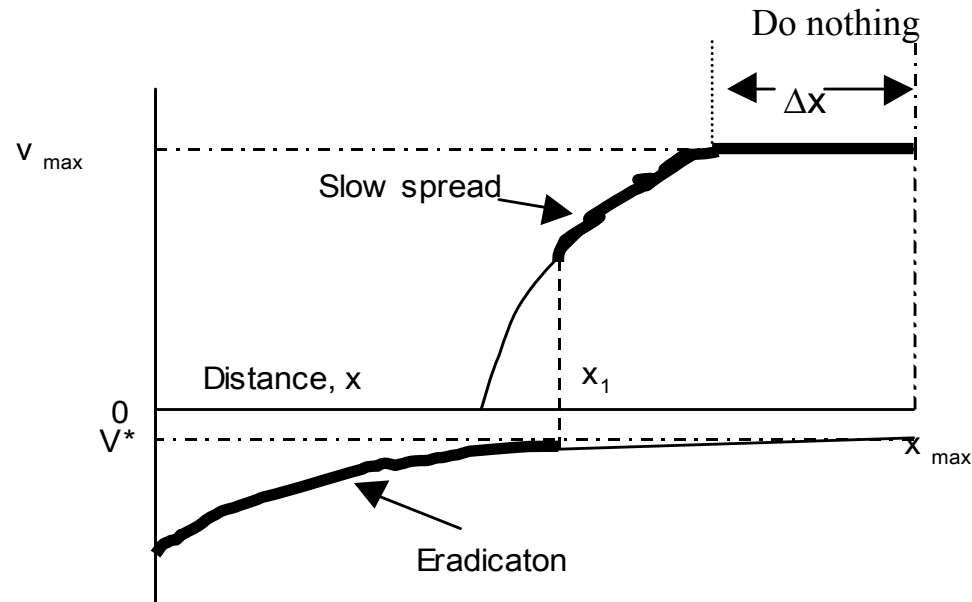
Yield Loss as a Function of Distance from the Source



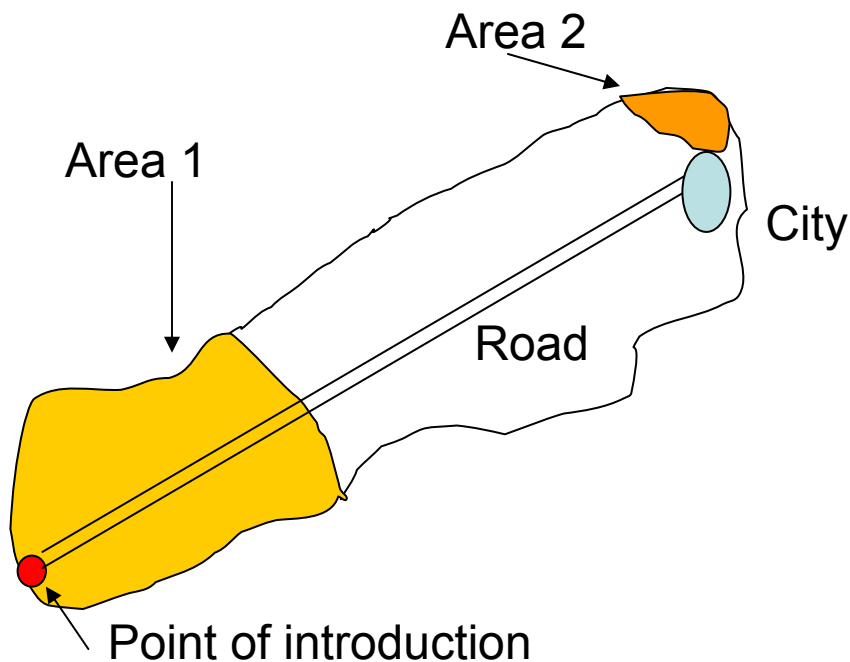
Damage < cost of control
 Globally:
 slowing spread
 dominates



Damage > cost
 of control



Assessing interrelationships

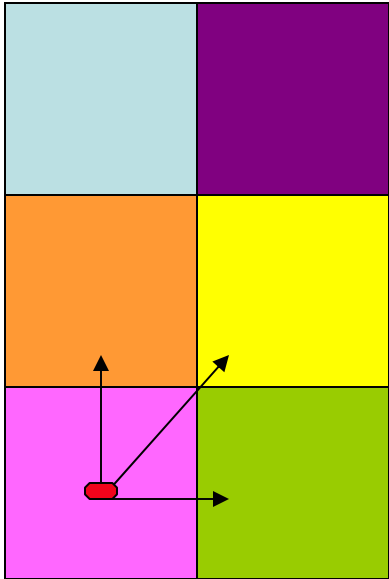


- How does Area 1's pest population affect introduction in Area 2?
- Yield loss in Area 1
- Yield loss in Area 2
- How does Area 1's control activities affect Area 2?
- How does Area 2's control activities affect Area 1?

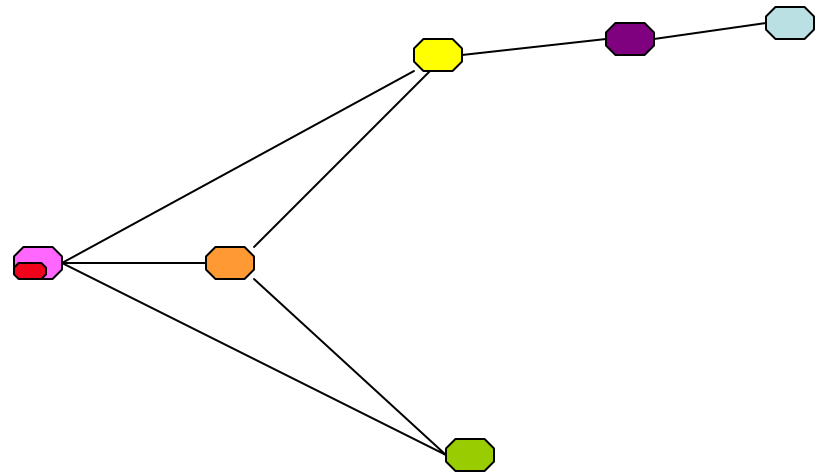
Spatial Relationships and Infestation

- n Is it contiguity: $(0,1)$
- n Is it distance: $(1/d)$ or (d)
- n Newtonian Gravity Models
- n Is it Weather Patterns for some species?
- n What Spatial level is relevant ?

Specification of spatial relationship

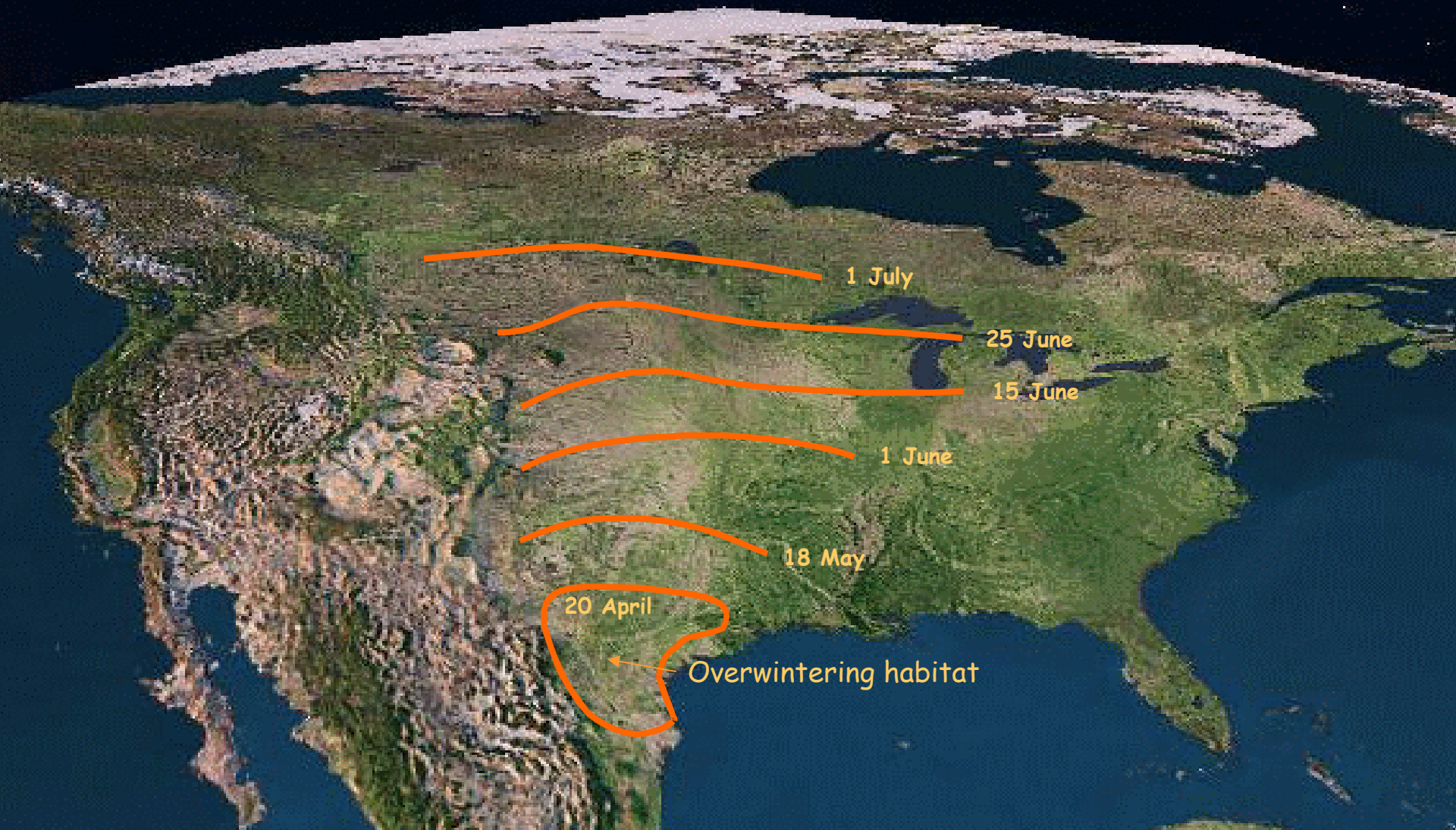


Contiguous (0,1)



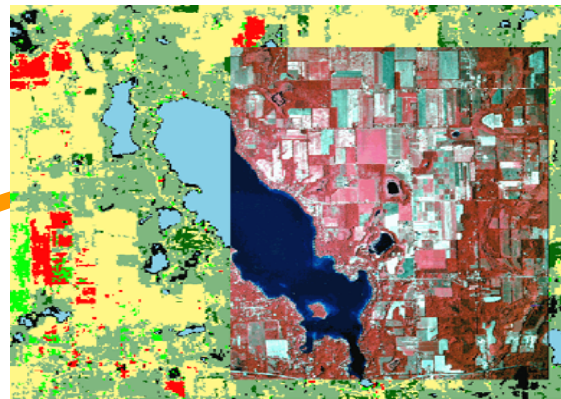
Distance Matters (d_{ij} , $1/d_{ij}$)

Aerial transport of wheat stem rust, April - July 1923

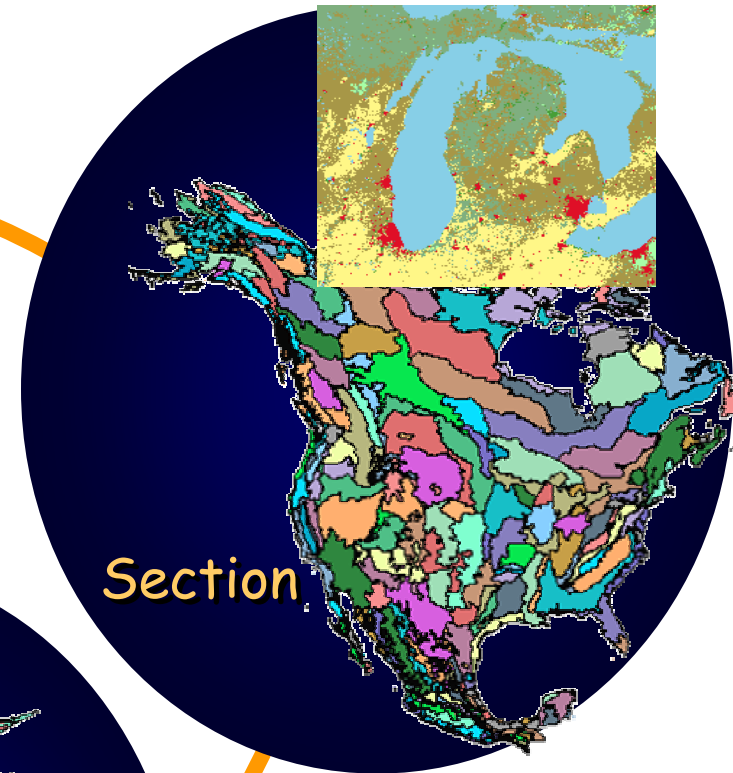




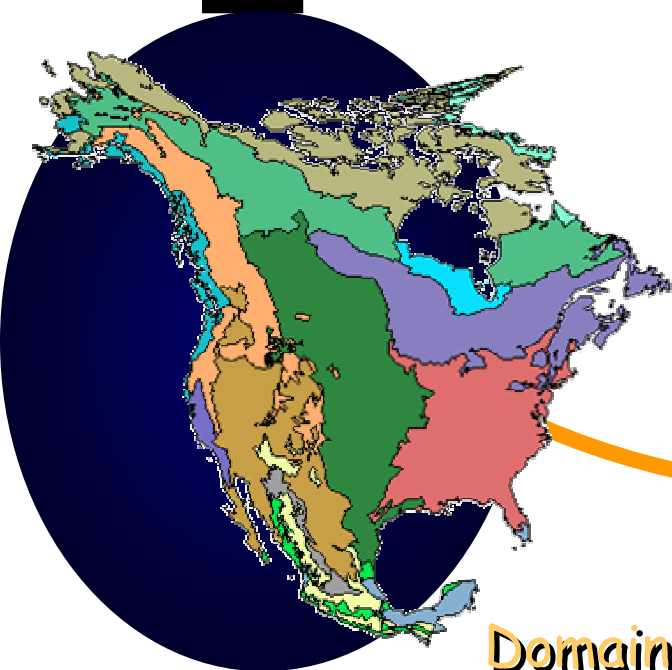
Habitat



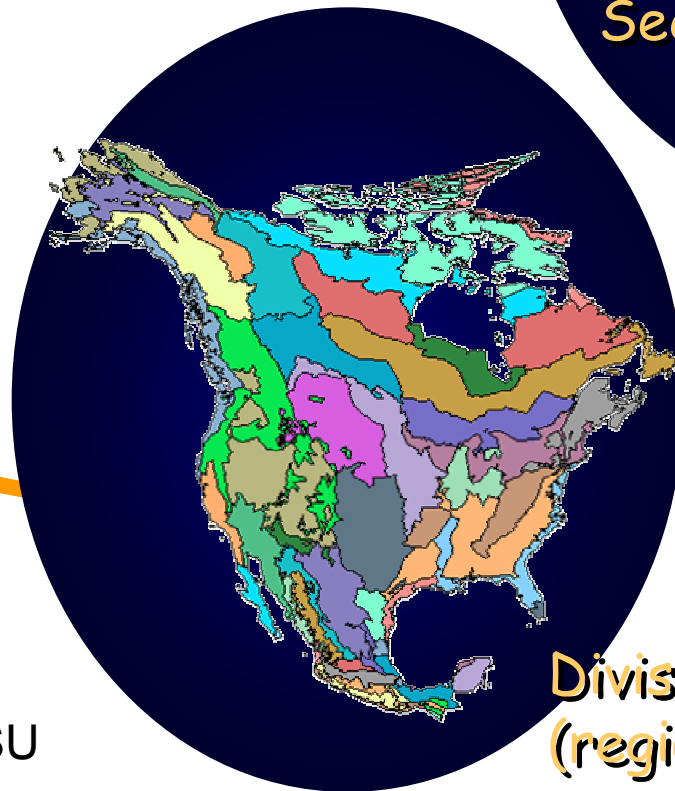
Landscape



Section



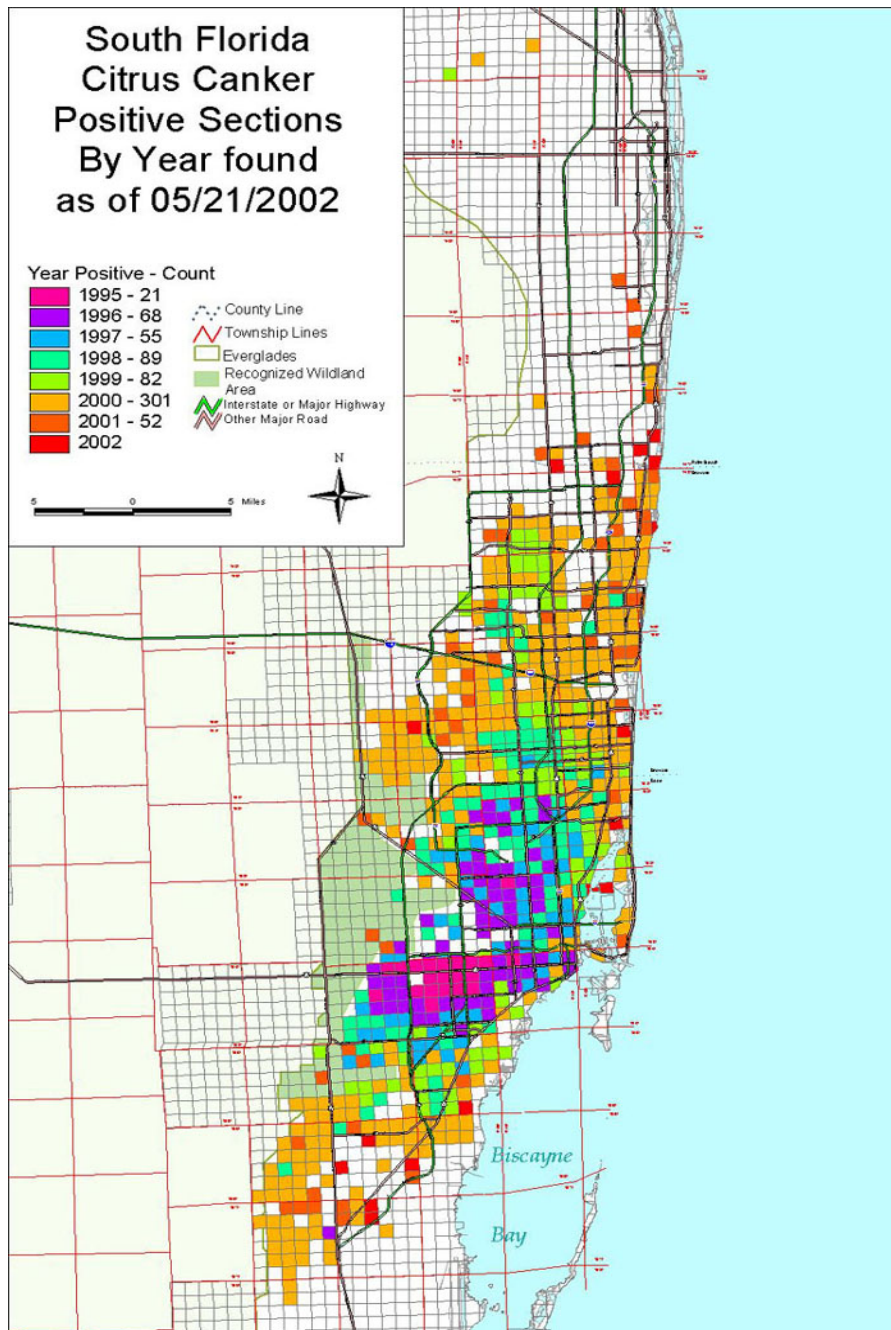
Domain



Division
(region)

Hierarchical
Scaling of
Geographic
Units

Stuart Gage, Scott Isard, MSU



Quarantined all areas affected
by evidence of citrus canker

All trees within 125 ft radius of
a diseased tree were
removed but spread
continued

Did a GPS-census of healthy
and diseased trees

Established a spatially based
disease gradient

Led to removal of all trees
within a 1,900-ft radius

793 square miles of trees
affected

Conclusions

- n Spatial dynamics are an important component in assessing:
 - n the potential introduction of an invasive species
 - n the potential establishment
 - n the optimal eradication or management strategy
 - n and targeting resources to greatest risk